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Stream Channel Monitoring in Northern Great Plains Network, Data Quality Standards

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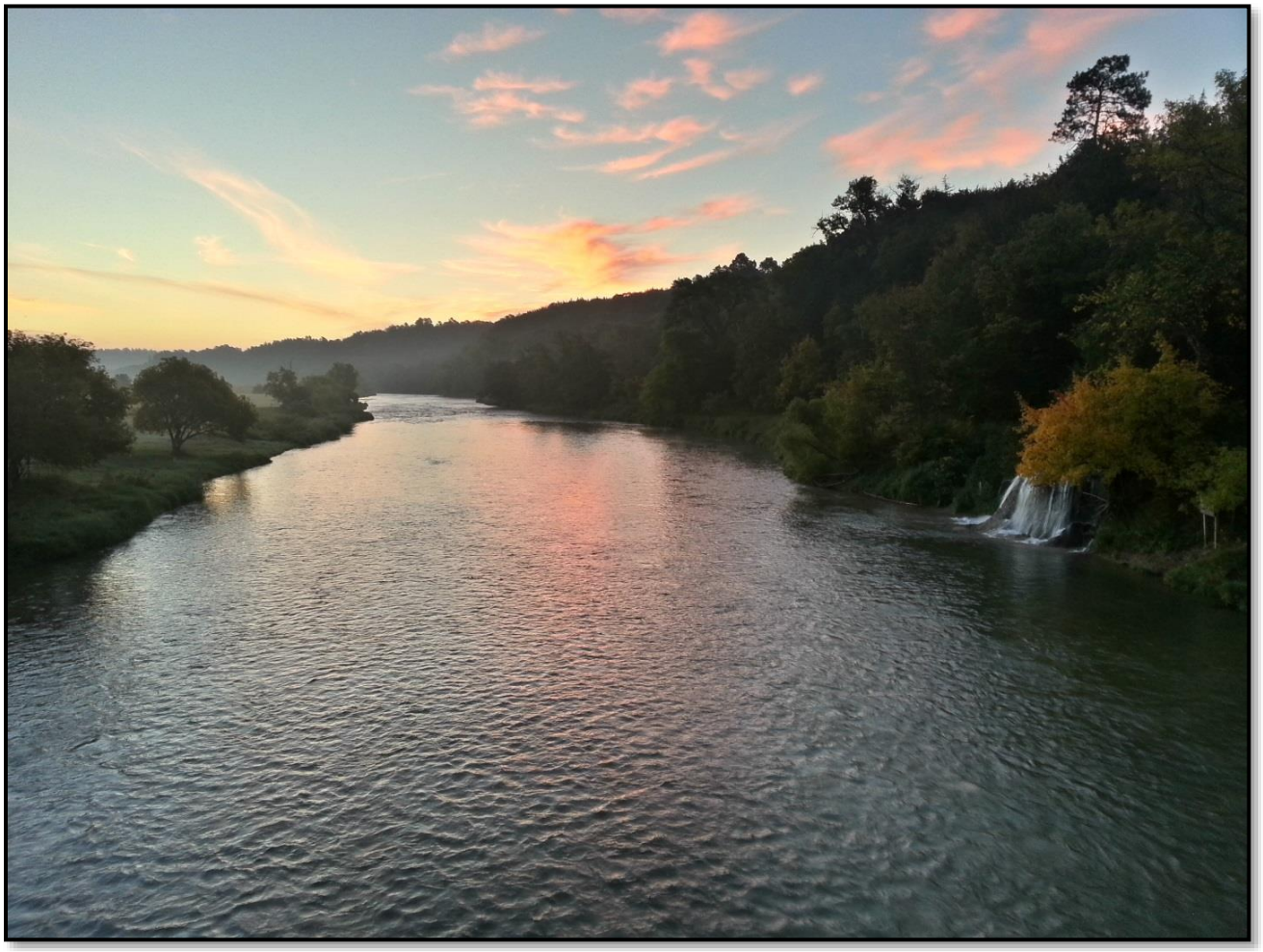
National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Stream Channel Monitoring in Northern Great Plains Network

Data Quality Standards

Natural Resource Report NPS/NGPN/NRR—2019/1919



ON THIS PAGE
Little Missouri River, Theodore Roosevelt National Park.
Photograph courtesy of D. Licht

ON THE COVER
Niobrara River, Niobrara National Scenic River near Sparks, Nebraska.
Photograph courtesy of M. Moser, United States Geological Service, Nebraska Water Science Center

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Executive Summary

The purpose of this report is to document the standards used by the Northern Great Plain Network (NGPN) for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in the *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). The plan also serves as a guide for all NGPN personnel who are involved in protocol/program activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

Introduction

The purpose of this report is to document the standards, used by the Northern Great Plain Network (NGPN) for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in the *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). The policies and procedures documented in this data quality standards (DQS) for activities complement other monitoring activities conducted by the Northern Great Plain Network and supplement National Inventory & Monitoring Division Quality Management Plan. The plan also serves as a guide for all NGPN personnel who are involved in protocol/program activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

Protocol Implementation Plan Overview

The NGPN has initiated a monitoring effort to assess stream channel characteristics and near-channel habitat condition in perennial wadeable streams and rivers at park units in the NGPN. These parks include Devils Tower National Monument, Knife River Indian Villages National Historic Site, Theodore Roosevelt National Park, Wind Cave National Park, Agate Fossil Beds National Monument, Niobrara National Scenic River, Mount Rushmore National Memorial, Fort Laramie National Historic Site, and Missouri National Recreational River.

Monitoring focuses on providing data needed to assess the channel characteristics and near-channel habitat condition in perennial streams and rivers at NGPN parks and how these channel characteristics change through time. The stream channel characteristics sampling methods proposed in the *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019) rely on standard data collection methods and standard operating procedures (SOPs) currently in use by the Southeast Coast Network (SECN, McDonald et al. 2018), U.S. Environmental Protection Agency (U.S. EPA 2013), NGPN, other IMD Networks that have been modified to meet the needs of NGPN and NPS park managers (Thornbrugh et al. 2019).

Both anthropogenic and naturally occurring stressors to the aquatic systems can create changes in stream/river channel characteristics, sediment loads, water quality and water supply, which affect biodiversity of biota, and alter riparian areas and wetlands (Longo and Yoskowitz 2002). For example, withdrawal of water resources associated with anthropogenic use within Nebraska, North Dakota, South Dakota, and Wyoming may result in withdrawal of water from aquifers faster than the aquifers are being recharged (Luckey et al. 1988; Johnson and Bouzaher 1995). Luckey et al. (1988) reported groundwater declines of 50–100 feet near NGPN park units in western Nebraska. These changes can have cascading impacts on other park resources. Changes in channel geomorphology is a threat in this region because of the extreme flow events. Changes in channel geomorphology can contribute to a reduction in active floodplains, reducing or eliminating recruitment of cottonwood and suitable nesting habitat for Piping Plovers and Least Terns, and pallid sturgeons (Gitzen et al.

2010). River erosion is also threatening cultural resources and landscapes at Fort Laramie, Fort Union and Knife River Indian Villages National Historic Sites (Gitzen et al. 2010).

To successfully monitor change in water resources, consistently applied protocols for the collection and processing of data are critical for ensuring that changes detected by stream channel monitoring are occurring, are defensible, and not a result of measurements taken by different people or different ways (Oakley et al. 2003). To better understand and monitor water resources, the Northern Great Plains Network has published two monitoring protocols. The largest focuses on continuous monitoring of water flow and chemistry at one location in each park and is done in collaboration with the United States Geological Survey (Wilson et al. 2014). A smaller protocol focuses on monitoring aquatic macroinvertebrate assemblages at Agate Fossil Beds National Monument (Peterson et al. 1999). Here, we present methods to monitor stream channel characteristics in nine national park units. A smaller, less detailed Protocol Implementation Plan (PIP) provides information about the published source document and then describes and justifies any differences between the implemented methods and the published source (NPS 2015). This streamlines the publication process and encourages consistency of methods across parks and partners. Stream and rivers are an important resource, understanding stream channel geomorphology is a critical vital sign, and a key part of the NGPN monitoring program for understanding water resources. Prioritization efforts by the Network and parks since the Vital Signs Monitoring Plan was published have reduced the scope of the stream channel characteristics monitoring efforts due to logistical and budgetary constraints. Therefore, NGPN has chosen to expedite protocol development by completing a PIP to describe and summarize stream channel monitoring and any deviations from published source protocols.

Measurable Objectives

The objectives of the PIP for Stream Channel Monitoring in the NGPN are for a set of fixed locations at nine parks sampled at a rate of nine years for watershed characteristics and three years for stream geomorphic dimensions and habitat features:

1. Determine the status of upstream **watershed characteristics** such as watershed area, catchment slope, and drainage density, and changes to land cover that may affect stream habitat.
2. Determine the status of and trends in the **geomorphic dimensions** (cross-sectional morphology) of selected wadeable stream reaches including channel widths, bank characteristics (e.g., heights, angles, and vegetative cover), and reach slope and sinuosity.
3. Determine the status of and trends in physical measures of benthic and riparian **habitat features** present in selected wadeable stream reaches such as the size, type, and distribution of bed sediment and large woody debris, the distribution of geomorphic channel units, canopy cover, and discharge.

Protocol Activities and Modules

Data are collected or derived as a part of the *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019) in 19 different activities or modules (Table 1).

Table 1. Protocol activity matrix for Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0 (Thornbrugh et al. 2019)

Category	Activity Number	Activity	Description
Site Selection, Recon, Establishment, and Maintenance	1	Site Selection and Recon	Site selection is a four step process. (1) Identification of potential stream segments in GIS that can be paired with NGPN Water Quality Monitoring sites, (2) Consultation with park staff, (3) Field evaluation of potentially suitable segments, (4) Final site/reach selection and sites collocated with USGS gauges and monitoring locations from NGPN Water Quality Monitoring Protocol (Thornbrugh and Mills 2019a)
	2	Site Establishment	Sample reach layout, initial evaluation of primary and standard transects and installation of primary and secondary index site markers (Thornbrugh and Mills 2019b)
	3	Site Maintenance	During each subsequent revisit, primary and secondary index site markers are relocated (Thornbrugh and Mills 2019a)
Field Observations	4	Geomorphic Dimensions	**Reach**: Longitudinal profile (reach slope), reach sinuosity, bearing sinuosity, thalweg sinuosity, reach discharge (Thornbrugh and Mills 2019b)
	5	Geomorphic Dimensions	**Transects**: Wetted width, active channel width, bankfull width, channel full width, floodplain width, thalweg position, thalweg depth, in-channel features, bankfull height, channel full height, bank undercut depth, bank undercut height, bank angle, bank sediment, bank erosion (presence and type), bank stability index (Thornbrugh and Mills 2019b)
	6	Geomorphic Dimensions	**Detail transects**: Bankfull area, bankfull perimeter, bankfull hydraulic radius, bankfull width, bankfull depth, bankfull width to depth ratio, channel-full area, channel-full perimeter, channel-full hydraulic radius, channel-full width, channel-full depth, channel-full width to depth ratio (Thornbrugh and Mills 2019b)
	7	Habitat Features	**Reach**: Large woody debris amount, volume, position and function, bed material (pebble count), distribution of geomorphic channel units (Thornbrugh and Mills 2019b)
	8	Habitat Features	**Transects**: Canopy closure, dominant particle size, dominant habitat, vegetative cover, ground cover (Thornbrugh and Mills 2019b)
Sensor Data	9	Photo Collection	Photos at reach transect locations. Take four photos, one photo facing downstream, upstream, left bank and right bank. Photos at primary and secondary index marker locations at site establishment and revisits (Thornbrugh and Mills 2019a)

Table 1 (continued). Protocol activity matrix for Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0 (Thornbrugh et al. 2019)

Category	Activity Number	Activity	Description
External Data	10	Water Quality Data	Water quality data: discharge, stage, temperature, pH, dissolved oxygen, and specific conductivity (Thornbrugh and Mills 2019c)
	11	Climate data from Applied Climate Information System (ACIS)	Weather station temperature and precipitation data from EnvironmentalSettingToolkit (Thornbrugh and Mills 2019c)
	12	National Elevation Dataset (NED)	Used in the calculation of the geomorphic descriptors for watershed assessment (Thornbrugh and Mills 2019d)
	13	National Land Cover Data Base (NLCD) datasets	Used in the calculation of land use and cover characteristics (Thornbrugh and Mills 2019d)
	14	National Hydrography Dataset Plus High Resolution (NHDPlus HR)	Used for sample site selection and stream reach representation in watershed assessment (Thornbrugh and Mills 2019d).
Derived Data	15	Watershed Characteristics	**Watershed**: Drainage area, total stream length, drainage density, basin length, watershed shape, average slope, standard deviation of slope, basin relief, basin relief ratio, standard deviation of elevation, entire stream gradient, and bifurcation ratio Land use/land cover (Thornbrugh and Mills 2019d)
	16	Watershed Characteristics	**Segment**: gradient and Strahler stream order (Thornbrugh and Mills 2019d)
	17	Summary Metrics	Descriptive statistics for measures outlined in activities 4-8, cross sectional areas, entrenchment ratios, and bank stability index.
	18	Response Metrics	Response metrics calculated from stream channel monitoring field measurements examples (Table 2)
Quality Control Data	19	Flow Meter Calibration	The flow meter will be calibrated in May of each year and double check two months before the field season. If flow meter readings fall outside manual specifications the instrument will be sent to manufacture for calibration. Any data collected with a faulty flow meter will be flagged as inaccurate, validated with existing data or discarded if validating data does not exist.

Table 2. Example of response metrics that can be calculated from stream channel field measurements (Kaufmann et al. 1999).

Objective	Measures or Metrics (Examples)	Units
Determine the status and trend in stream condition via physical habitat.	Volume of Woody Debris per m2 of bankfull channel area	m^3/m^2
	Streambed Sand & Finer (<2 mm)	%
	Relative Bed Stability (mean bed particle diameter/critical (mobile) diameter at bankfull	log
	Channel Sinuosity	Unitless
	Incision from terrace to bankfull height	m
	Bankfull Width/Depth Ratio	log
	Low flow/annual mean runoff (inverse index of “droughtiness”)	log
	Bankfull depth/wetted depth (a morphometric index of “flashiness”)	log
	Hydrograph-based metrics for sites with gauges and a long-term record of discharge: Annual total discharge, Annual mean discharge, Highest annual mean, Lowest annual mean, Highest daily mean, Lowest daily mean, Maximum peak flow, Annual seven-day minimum, Annual seven day maximum, April, May, June, July discharge as a percent of the total annual discharge	Various (cm, days)

Sampling Design

Information regarding the sampling design is provided in Table 3.

Table 3. Activity-level sample design matrix for *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). Numbers (left column) match those in the protocol activity matrix (Table 1).

Category	Activity Number	Activity	Sampling Design	Revisit Design
Field Observations	4-6	Geomorphic Dimensions	Index site; collocated and visit index sites with NGPN water quality monitoring schedule (Wilson et al. 2014)	three years
	7-8	Habitat Features	Index site; collocated and visit index sites with NGPN water quality monitoring schedule (Wilson et al. 2014)	three years
	15-16	Watershed Characteristics	Associated watershed of index site; calculated on a cycle of updated land cover data and trend reports (McDonald et al. 2018)	nine years
Sensor Data	9	Photo Collection	Index site; collocated and visit index sites with NGPN water quality monitoring schedule (Wilson et al. 2014)	three years

Data Quality Objectives

Data quality values and standards for implementation are provided in Table 4 and **Error! Reference source not found.**5.

Table 4. Data Quality Values (DQVs) for *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019).

Category	Data Quality Value	Definition	Protocol Considerations
Intrinsic Data Quality	Accuracy	Measurements reflect the true value of the parameter being observed. This applies to measures (length, width, position) or classes (species, types, or categories). Includes components of precision and bias.	Plans for protocols, programs, or projects specify accuracy requirements designed to ensure desired results, considering estimated or expected precision and bias. May be of heightened importance for protocols where data are known or expected to be used in legal, regulatory, or policy situations. Accuracy varies depending upon the specific reach or transect scale measure. The accuracy of these data allows for change and differences to be measured and quantified through time at sites. The expected repeatability of these measurements is within 5–10% of the measurement depending on the parameter.
	Representativeness	Measurements represent conditions at the time of sampling. Combined with accuracy, leads to repeatable data collection.	Parameters and methods are chosen such that they measure representative conditions. Measurements may be direct measures, indexes, or indicators of conditions. At every sample reach, measures of stream morphology and riparian habitat are collected at 11 standard transects. Three of these are also detailed transects. These data provide a representative understanding of reach-scale conditions at each site. Data are collected concurrent in time such that they represent habitat conditions/measures that can be used as ecological covariates for other vital signs being collected by the network. Coordinated field site locations, frequency and sampling schedule between two network vital signs (i.e., stream channel characteristics and water quality) may provide a more integrated assessment of ecological conditions of water resources in the NGPN and in some cases, insight into underlying cases of environmental change of core water quality parameters and stream channel characteristics.

Table 4 (continued). Data Quality Values (DQVs) for Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0 (Thornbrugh et al. 2019).

Category	Data Quality Value	Definition	Protocol Considerations
Contextual Data Quality	Comparability	The degree to which data can be compared among sample locations, data sources, or periods of time.	For IMD it is assumed for most protocols that data must be comparable over time in order to conduct trend analyses. If the intent for data analysis is to combine IMD data with other data sets (other networks, other agencies), there may be some considerations necessary in terms of training, equipment, standards, sampling design, index period, etc.). If training guidelines, equipment maintenance, and suggested sample windows are maintained as outlined in the protocol, uncertainties in the dataset will be minimized, and differences in space and time will be identifiable and measurable through spatial and trend analyses. Data are collected using methods employed by other I&M networks to allow for comparison of conditions across parks within and external to the NGPN.
	Timeliness / Currency	How recent the data need to be considered valid for their intended use. Data represents conditions and/or is available and in a format for use at the appropriate time in the decision-making process.	Data processing occurs in a timely fashion based on certification requirements and intended use of data. Where certified data cannot be provided for resource management decisions in a timely manner, requirements for provisional use of data are defined and documented prior to data dissemination and use.
	Completeness	All data/ measures required to evaluate accuracy representativeness are present; incomplete data sets (either at a location, across sampling locations, or over time) lose utility or relevance. Data records contain values as planned across the period of record.	Methods, sampling plans, and analyses are designed and implemented such that they result in a complete dataset across space and the planned period of record. Note that this value is for a collection of data records; how many measures are deemed valid and suitable for use at the completion of all QA/QC procedures. Data sheets are checked prior to leaving each site to ensure that all data were collected and recordings are legible. If, upon returning to the office, the data are found to be less than 100 percent complete, data that are missing are noted and these metrics/characteristics will not be included in subsequent analyses.

Table 4 (continued). Data Quality Values (DQVs) for Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0 (Thornbrugh et al. 2019).

Category	Data Quality Value	Definition	Protocol Considerations
Representational Data Quality	Consistent Representation	Use of standard definitions when describing data quality or resource quality based on data	This is particularly relevant when reporting data in comparison to management, ecological, or regulatory thresholds. Networks should consider establishing a consistent framework so that conditions are reported the same way over time and across parks where protocols are implemented (i.e., for condition assessments a rating of "good" always means the same thing). All diagnostic geomorphic surfaces and points surveyed along each transect are labeled using a standardized code. All categorical measures (e.g., type of bed material size class, type of geomorphic channel unit, riparian vegetation cover, human influence, and large woody debris tally) are labeled using a pre-determined set of codes or category.
Data Accessibility	Secure	Access to data, products, and systems limited to appropriate audiences.	Networks must identify and ensure that potentially protected data, including sensitive species location data, sensitive cultural resource information, and other data as protected by DO#66 are not released to the public. Protected data may be released in limited cases only with park Superintendent approval following park procedures. It is not anticipated that any sensitive or protected data will be collected during the implementation of this protocol. All personal identifiable information will be redacted from data before public release except as stated in Table 6.

Table 5. Measurement quality objectives for Data Quality Values (DQVs) for *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). Activities match those in the protocol activity matrix (Table 1).

Activity	Activity Number	Measure / Quality Indicator	Quality Objective
Site Recon and Selection	1	Sample Reach Accuracy	Navigate to within 50 meters of proposed reach coordinates.
Establishment	2	Site Location Accuracy	Index site marker locations are located within 0.01 meter of established coordinates (x, y, z).
Maintenance	3	Site Location Accuracy	Index site marker locations are located within 0.01 meter of established coordinates (x, y, z).

Table 5 (continued). Measurement quality objectives for Data Quality Values (DQVs) for *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). Activities match those in the protocol activity matrix (Table 1).

Activity	Activity Number	Measure / Quality Indicator	Quality Objective
Geomorphic Dimensions	4	Accuracy	**Reach**: • ± 0.0005 m/m for longitudinal profile (channel slope) (total station point accuracy ± < 0.01 m) • ± 5 degrees for reach sinuosity • ± 5 degrees per meter for bearing sinuosity • ± 10% of mean for thalweg sinuosity • ± 5% discharge; for distance from bank, stream depth, and velocity
	5	Accuracy	**Transects**: • ± 5% of stadia rod measurements less than 1.5 m or ± 10% of stadia rod measurements greater than 1.5 m for wetted width, active channel width, bankfull width, channel full width, floodplain width, bankfull height, channel full height, bank undercut depth, bank undercut height, thalweg depth • ± 10% for thalweg position • ± 10 degrees for bank angles • Binary – in-channel features and undercut presence • Categorical measures- bank undercut presence, bank sediment, bank erosion (presence and type)
	6	Accuracy	**Detailed transects**: ± 0.1 m for diagnostic point coordinates (total station point accuracy ± < 0.01 m) used to calculate: bankfull area, bankfull perimeter, bankfull hydraulic radius, bankfull width, bankfull depth, bankfull width to depth ratio, channel-full area, channel-full perimeter, channel-full hydraulic radius, channel-full width, channel-full depth, and channel-full width to depth ratio
	4	Resolution	**Reach**: • Longitudinal profile (channel slope) measured to the nearest 0.0001 m/m Reach sinuosity to the nearest degree • Bearing sinuosity to the nearest degree • Thalweg sinuosity to the nearest degree • Discharge; distance from bank is measured to the nearest tenth of a foot • Stream depth is measured to the nearest tenth of a foot • Velocity 0.01 ft/s

Table 5 (continued). Measurement quality objectives for Data Quality Values (DQVs) for *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). Activities match those in the protocol activity matrix (Table 1).

Activity	Activity Number	Measure / Quality Indicator	Quality Objective
Geomorphic Dimensions (continued)	5	Resolution	**Transects**: • Wetted width, active channel width, bankfull width, channel full width, floodplain width, bankfull height, channel full height, bank undercut depth, bank undercut height, and thalweg depth are measured to the nearest 0.01 m • Thalweg position is estimated to the nearest 5% • Bank angles is measured to the nearest 0.1 degree • Binary – in-channel features and undercut presence • Categorical measures- bank undercut presence, bank sediment, bank erosion (presence and type)
	6	Resolution	**Detailed transects**: Coordinates used to calculate bankfull area, bankfull perimeter, bankfull hydraulic radius, bankfull width, bankfull depth, bankfull width to depth ratio, channel-full area, channel-full perimeter, channel-full hydraulic radius, channel-full width, channel-full depth, and channel-full width to depth ratio are measured to the nearest 1.0 mm
Habitat Features	7	Accuracy	**Reach**: • ± 2% of mean for large woody debris (LWD) amount • ± 2% of mean for LWD volume • ± 2% of mean for bed material (pebble count) • ± 10% of the mean for distribution of geomorphic channel units, • ± 10 % of the mean for reach average for canopy cover • Categorical measures- LWD position, LWD function
	8	Accuracy	**Transects**: • ± 5% per transect for transect average for canopy cover • ± 1 Wentworth size class for bed and bank sediment • ± 10% for vegetative and total ground cover • Categorical measure – geomorphic channel units (dominant habitat)

Table 5 (continued). Measurement quality objectives for Data Quality Values (DQVs) for *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). Activities match those in the protocol activity matrix (Table 1).

Activity	Activity Number	Measure / Quality Indicator	Quality Objective
Habitat Features (continued)	7	Resolution	**Reach**: • Large woody debris (LWD) amount is a total count • LWD volume to the nearest 0.01 m3 • Bed material (pebble count) measured to the nearest 1 mm • Distribution of geomorphic channel units to the nearest 5% • Reach average canopy cover to the nearest 5% • Categorical measures- LWD position, LWD function
	8	Resolution	**Transects**: • Canopy cover is to the nearest 1% • Bed and bank sediment are to the nearest Wentworth size class • Vegetative and total ground cover are to the nearest 5% • Categorical measure – geomorphic channel units (dominant habitat)

Table 6. Data protection standards for *Protocol implementation plan for stream channel monitoring in the Northern Great Plains Network: narrative version 1.0* (Thornbrugh et al. 2019). With the exceptions noted, all data collected are to be made publicly available in a timely fashion.

Category	Type of Data	Level of Protection	Rules for Dissemination
Personal Identifiable Information	Non-NPS Staff Information	Legally Protected	All but first name and last initial redacted from public release

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